Cooling of High-Intensity ISOL Beams

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Beam cooling → reduces beam emittance and energy spread

Better ISOL beam quality – better RIA performance and experiments

Cooled beams reduce challenge of isobar separation - cost saver

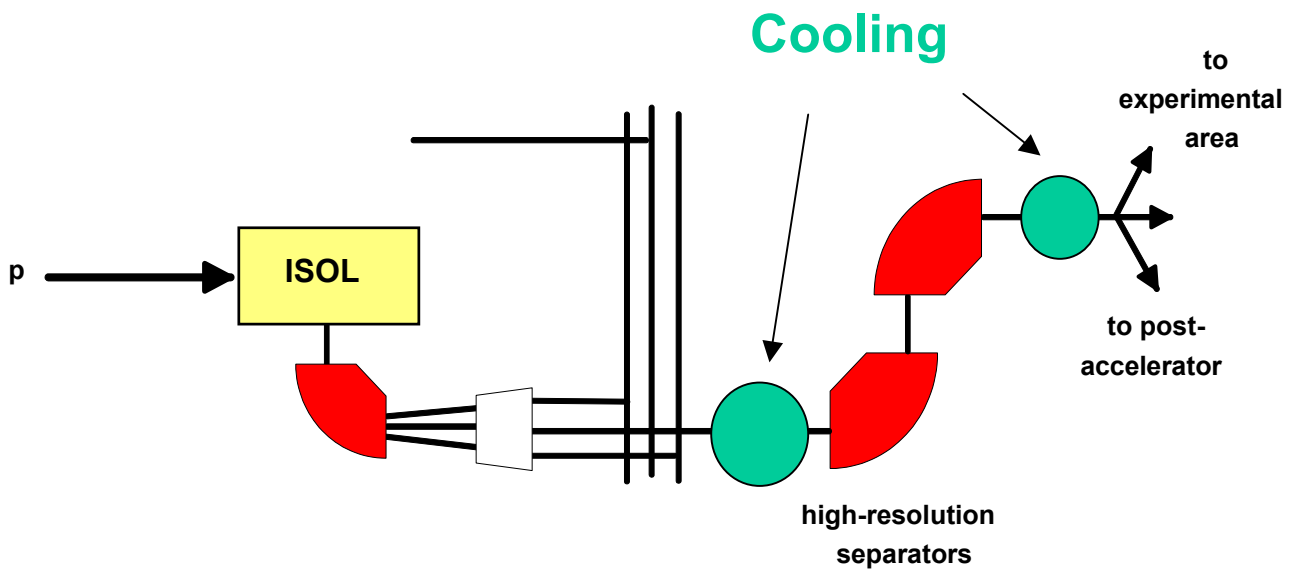
Beam looses history after cooling – easier beam tuning and operation

Beam Cooling of ISOL Beams at RIA

Beam properties vary with ion source type and operation
Long beam transport to separators does not improve beam quality

Typical: 10-25 π mm mrad @ 30 keV[$], ΔE ≤20eV

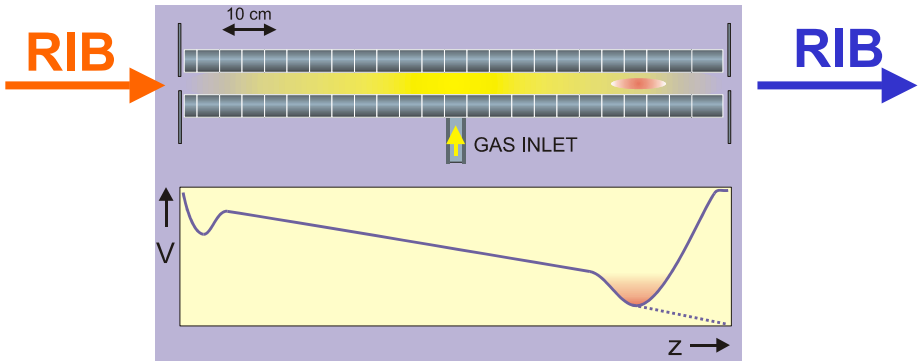
[$]F. Wenander et al., NIM B204 (2003) 261



Recognized Method of Choice

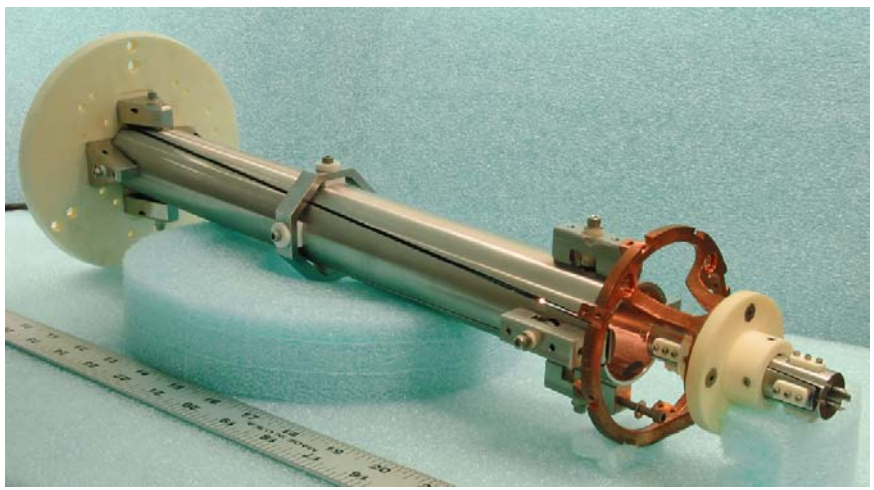
Buffergas cooling in RF multipole ion guides or similar devices

Linear RF ion guides and traps



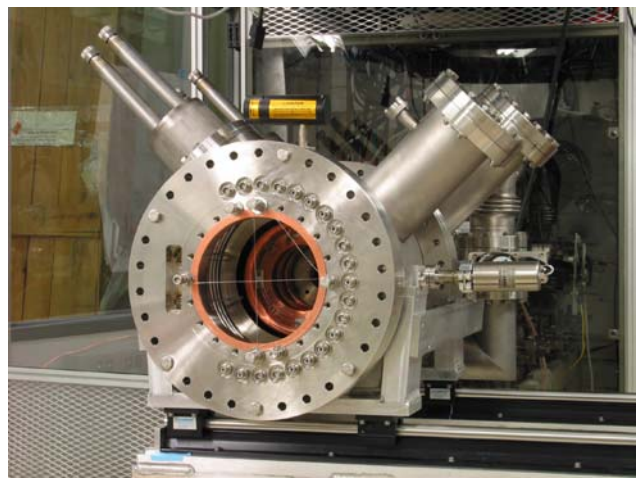
ISOLDE, JYFLTRAP, RIKEN, Louvain-la-Neuve, ANL, NSCL/MSU, HRIBF/ORNL, GSI,…

New generation: Cryogenic ion cooler for LEBIT at the NSCL



Linear ion trap with novel electrode system

S. Schwarz et al., NIM B204 (2003) 474



Cryogenic system (80K)

Rare isotope beam cooling works, but …

- Present ion cooler based on RF ion guides/traps have shown to work very well for low-intensity beams (few nA)
- Room for development: new systems use different geometries, cryogenic temperatures

… does it work at RIA beam intensities of many microamperes?

Status of high intensity beam cooling

- Hardly any systematic experimental study of space charge effects in beam cooling so far
- Until recently no realistic simulation that includes space charge
- First-order extrapolations do not exclude that this is possible
  (R.B. Moore and O. Gianfrancesco, NIM B204 (2003) 557)

Experiment

Simulations Results

Preliminary

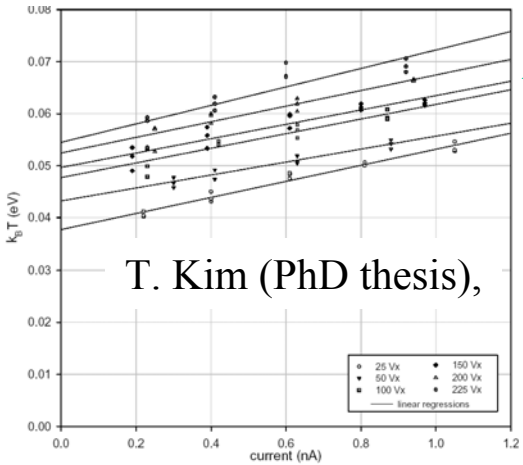
NSCL

T. Kim, R.B Moore, McGill, Montreal

Beam size as a function of beam current → beam temperature assuming no space charge

r_0 = 7 mm, Cs^+/N_2, p = $8 \cdot 10^{-2}$ mbar

U_{RF} = 300 V, f_{RF} = 0.7 MHz, E = 1 V/m

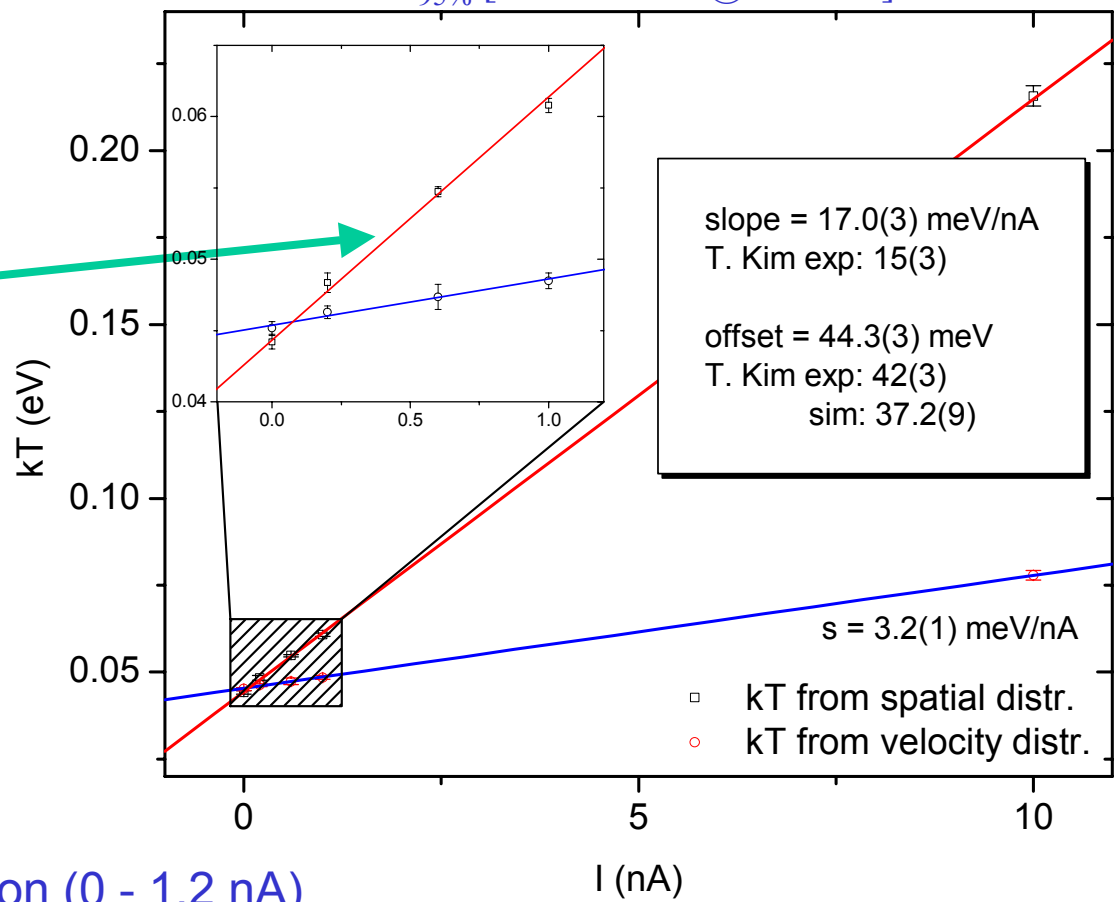


T. Kim (PhD thesis),

New, fast and efficient code at NSCL:

RF + Buffer gas collisions + Coulomb interaction

0.8 $\varepsilon_{95\%}$ [π mm mrad @ 60 keV] 2.3



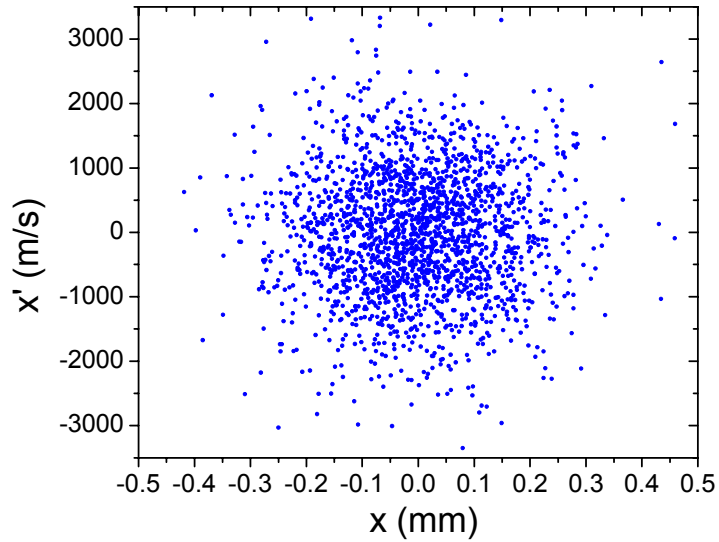
Agreement for spatial distribution (0 - 1.2 nA)
& slow rise of beam temperature

Towards high intensity beam coolers

preliminary

1-microampere simulation

$U_{RF} = 15$ kV, $f_{RF} = 5$ MHz, $E = 10$ V/m



$\varepsilon_{95\%} \approx 3\ \pi$ mm mrad @ 60 keV

looks promising

R&D

- **More simulations** to identify best operational scenarios and geometries
- **Build prototype** of high intensity cooler and study properties
- Consider space charge compensation with negative ions
- After verification that beam cooling at high-intensities is possible, incorporate in RIA concept and then decide on isobar separator

Improved RIA ISOL beams - Cost reduction - Better operation